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(54) **OUTBOARD MOTOR**

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Apr. 16, 2014 (JP) 2014-084959

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B63H 23/30 (2006.01)
B63H 20/28 (2006.01)

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(58) **Field of Classification Search**
CPC B63H 20/14; B63H 20/28; B63H 23/30
See application file for complete search history.

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(57) **ABSTRACT**

An outboard motor includes a drive shaft that transmits rotational power from an engine, a shift unit provided in the middle of the drive shaft, and a water pump that feeds a coolant to the engine. The drive shaft has a first input shaft that receives rotational power transmitted from the engine and a second input shaft that receives rotational power transmitted from the first input shaft. The shift unit has an upper gear rotating in synchronization with the first input shaft, an intermediate gear meshing with the upper gear at all times, and an intermediate shaft extending to the rear side from the intermediate gear and rotating in synchronization. The oil pump as an accessory is operated by the rotational power transmitted to the intermediate shaft.

6 Claims, 8 Drawing Sheets

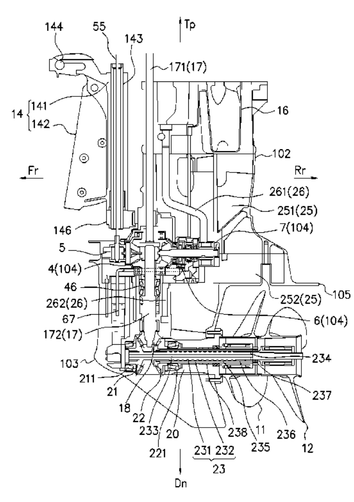

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Fig.1

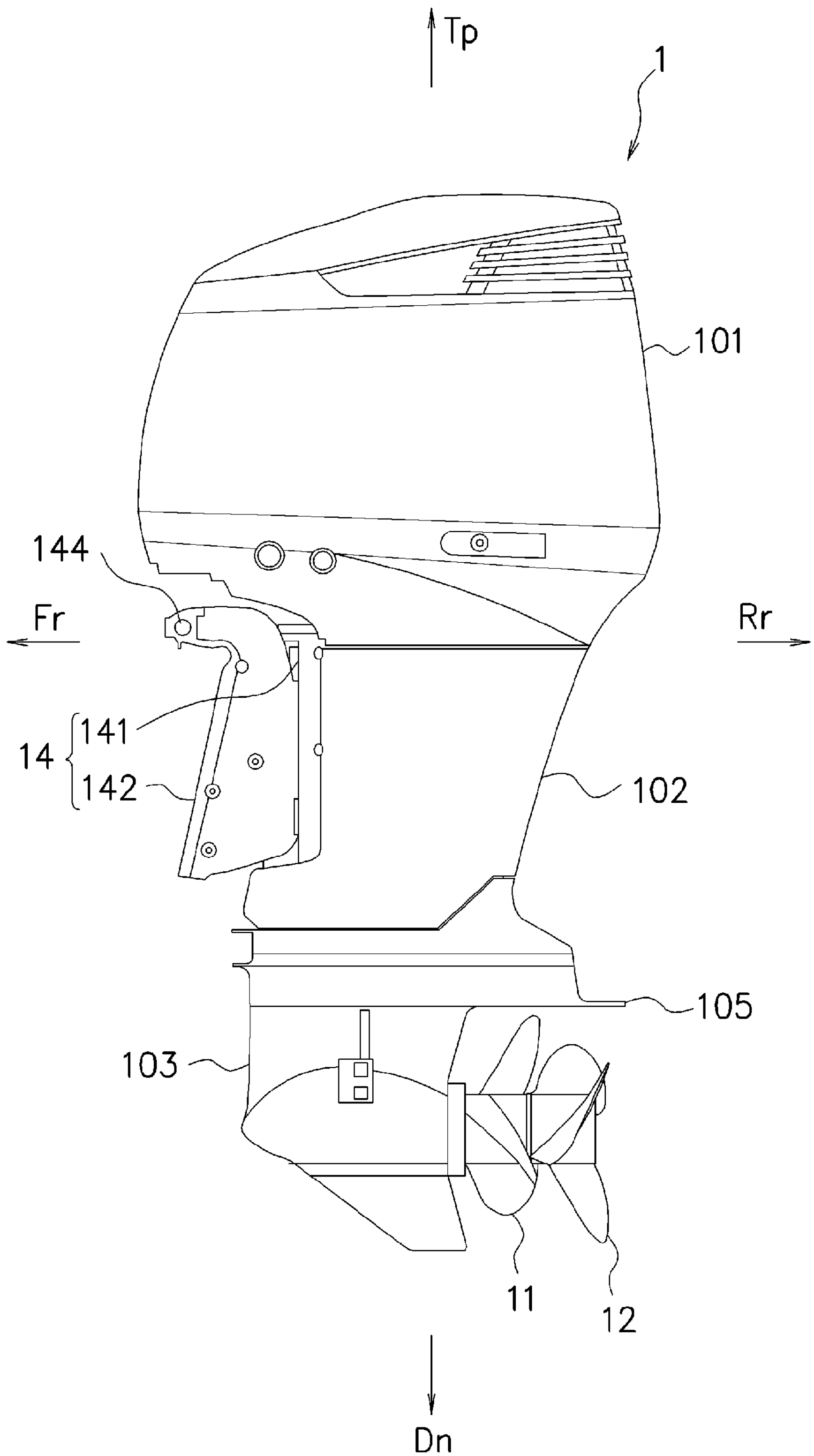
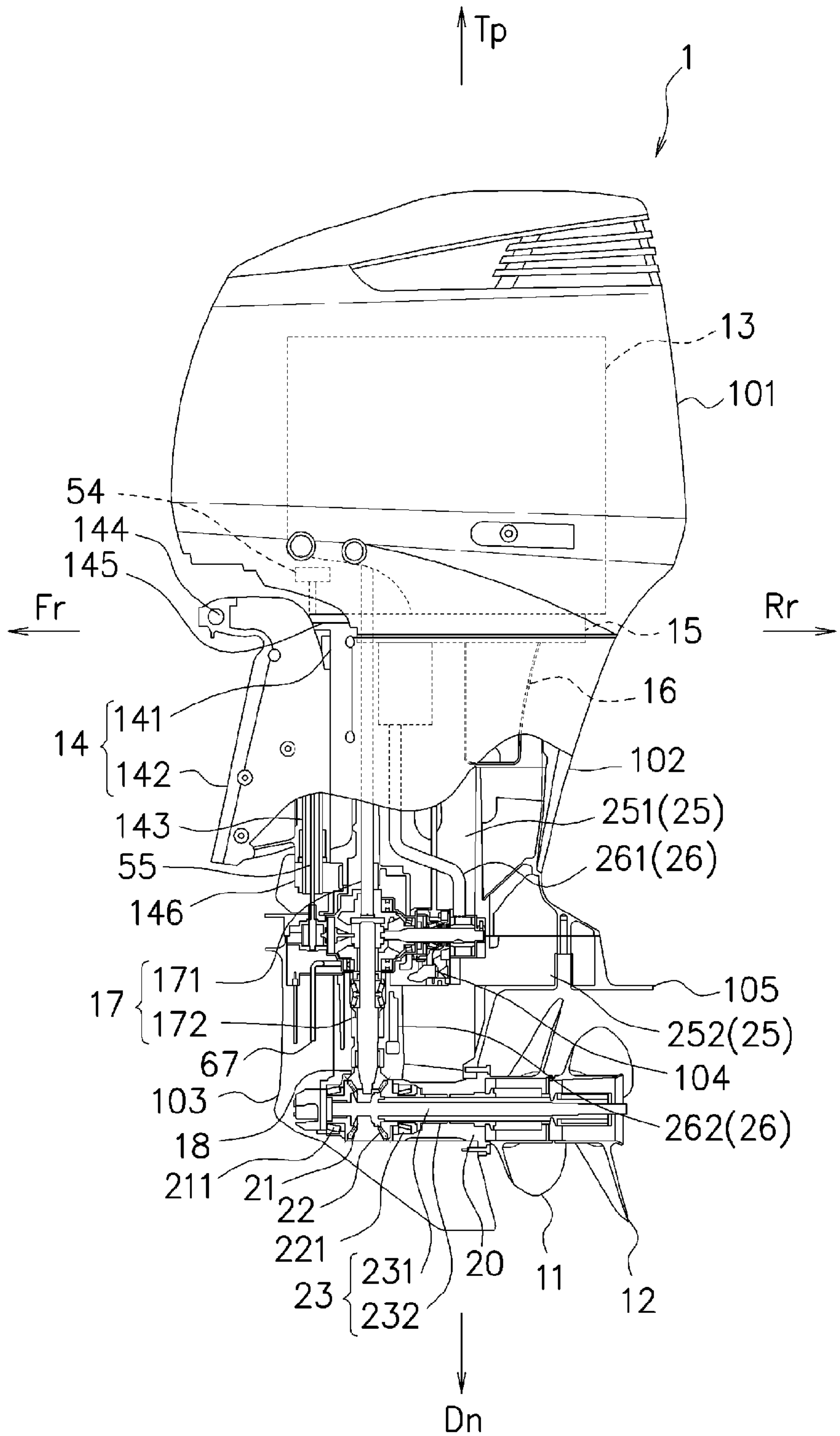


Fig.2



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101
54
144
145
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Rr
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142
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251(25)
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261(26)
146
105
17
171
172
252(25)
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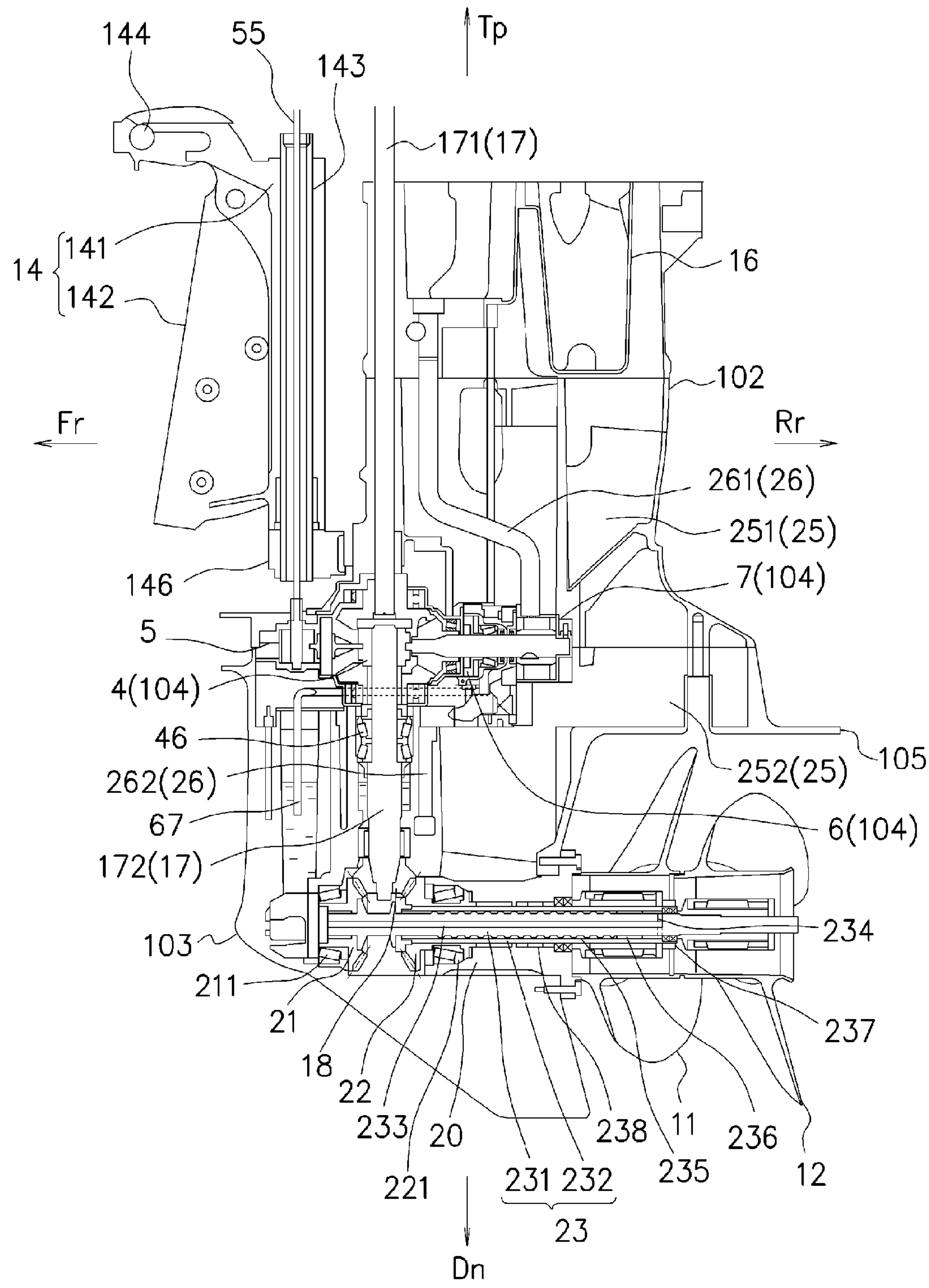
262(26)
18
211
21
22
221
20
11
12
23
231
232
Dn

Fig.3



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251(25)
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5
4(104)
46
105
262(26)
252(25)
67
6(104)
172(17)
103
234
211
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237
18
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233
20
221
238
11
236
231 232
23
235
12
Dn

Fig.4

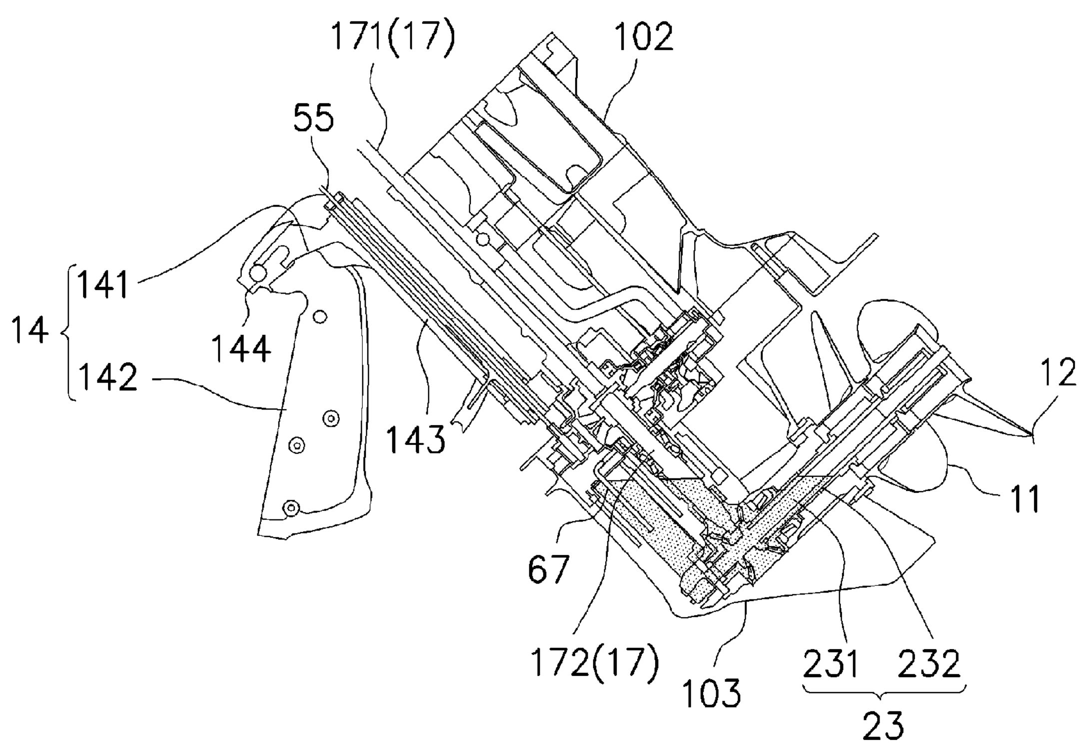
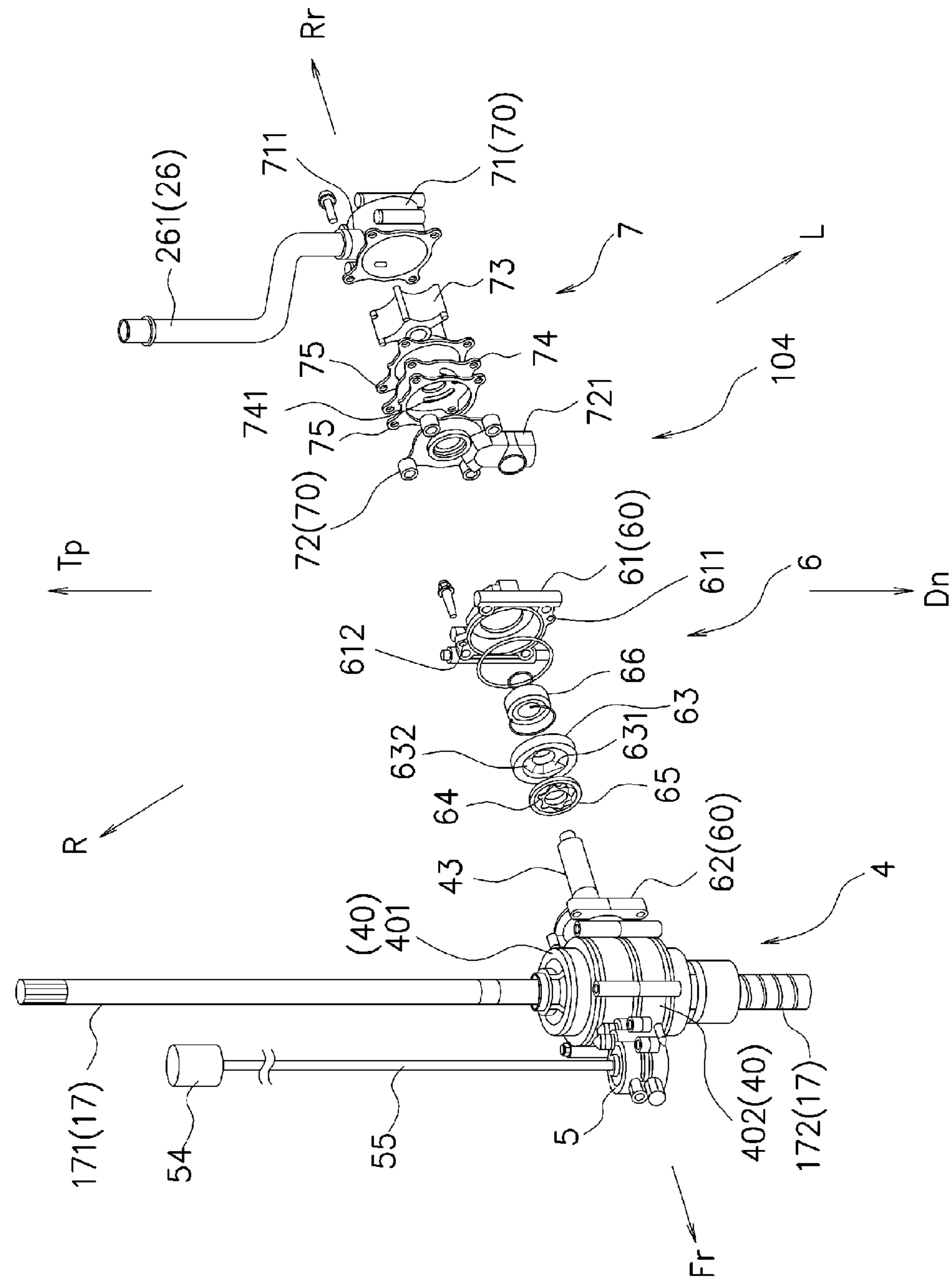


Fig.5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(40)
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171(17)
54
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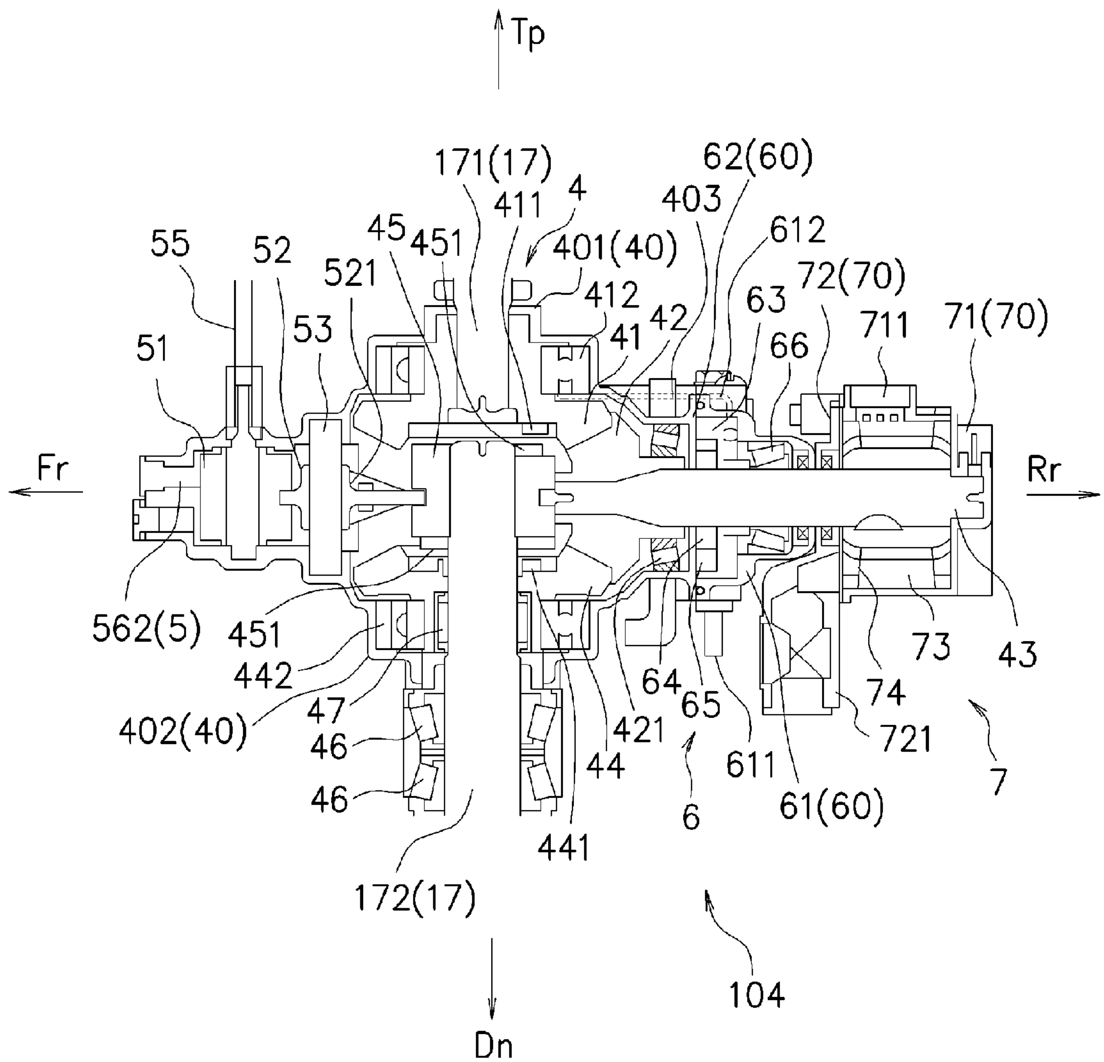
402(40)
172(17)
Fr

Fig.6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104

Fig.7

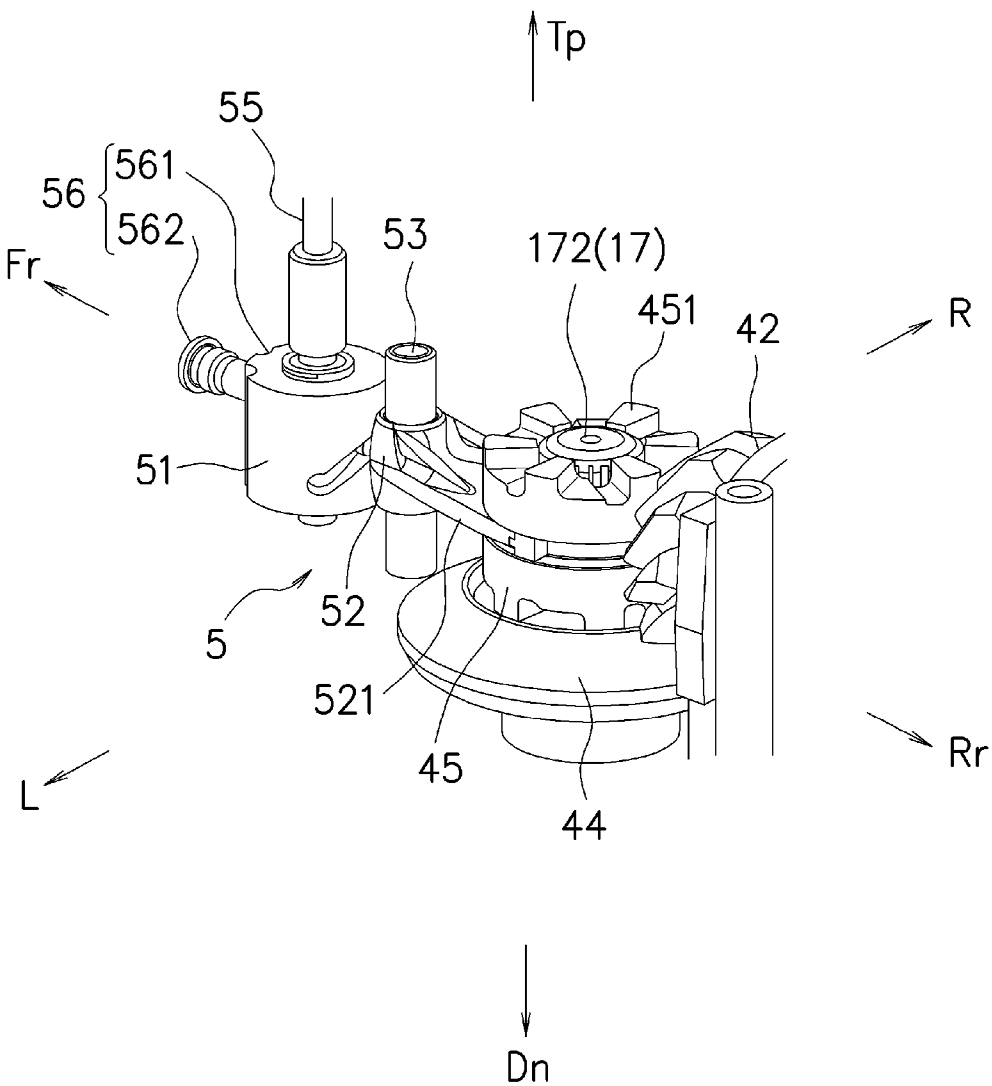
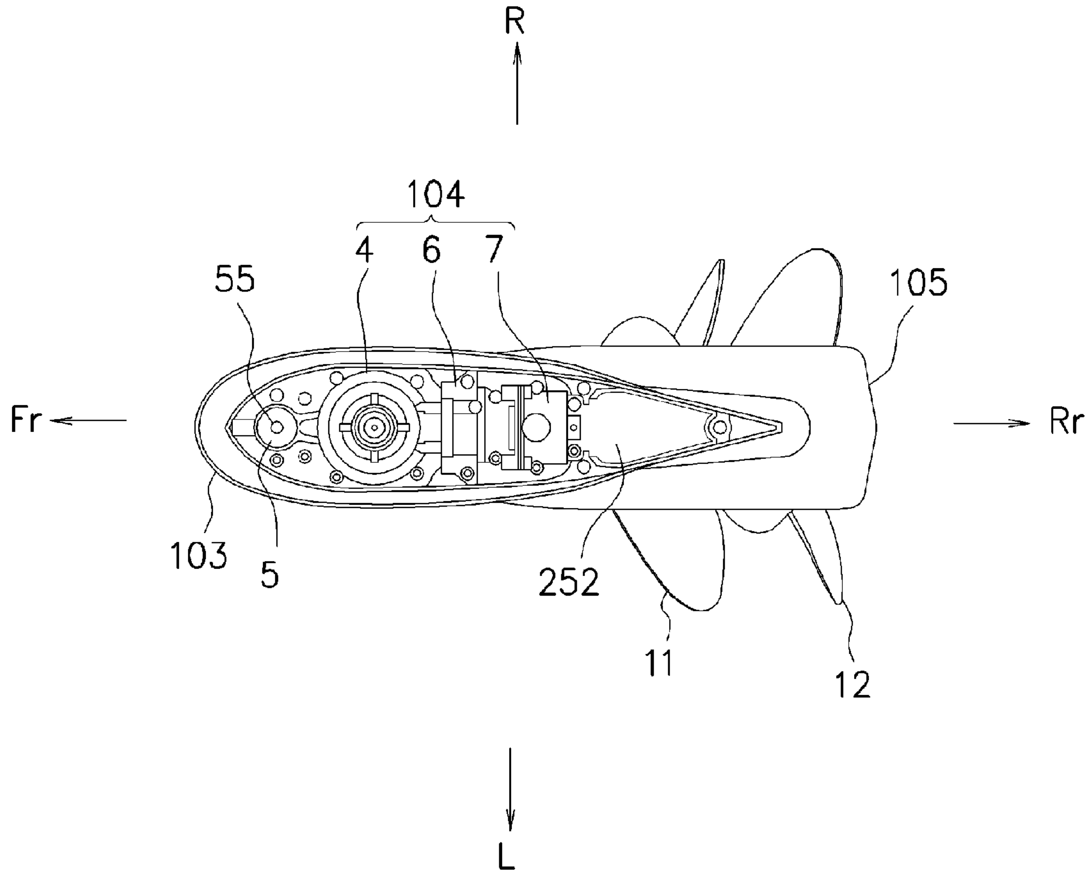


Fig.8



OUTBOARD MOTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of PCT International Application No. PCT/JP2015/061515, filed on Apr. 14, 2015 and designated the U.S., which claims the benefit of priority of the prior Japanese Patent Application Nos. 2014-084925, filed on Apr. 16, 2014 and No. 2014-084959, filed on Apr. 16, 2014, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to an outboard motor, and more particularly, to an outboard motor having a shift unit provided in the middle of a drive shaft that transmits rotational power from an engine to a propeller shaft to switch a shift position.

BACKGROUND ART

As a power source, an outboard motor mounted to an engine (internal combustion engine) typically has a shift unit that performs control of connection/disconnection of rotational power output from the engine and switches a rotation direction, an oil pump that feeds oil (lubricating oil) to the shift unit, and a water pump that feeds a coolant to the engine.

In Patent Literature 1, there is discussed an outboard motor provided with a drive shaft extending straightly downward from the engine and having first and second input shafts and a shift unit provided between the first and second input shafts. In addition, in the configuration discussed in Patent Literature **1**, an oil pump for feeding oil to the shift unit is operated by receiving rotational power transmitted via an inner shaft directly connected to the second input shaft.

However, this configuration has the following problems. The second input shaft receives the rotational power transmitted from the first input shaft via the shift unit. For this reason, if the shift position is set to a neutral position, the rotational power is not transmitted to the second input shaft, and the oil pump is not operated. Therefore, when the shift position is set to the neutral position, it is difficult to feed the oil to the shift unit.

Furthermore, in the configuration discussed in Patent Literature 1, the water pump is provided over the shift unit. The water pump is provided on the drive shaft and is operated by receiving the rotational power transmitted from the drive shaft. In this configuration, during the operation of the engine, it is possible to operate the water pump regardless of the shift position of the shift unit.

A pilot shaft serving as a center of steering of the outboard motor is provided in front of the drive shaft of the outboard motor. For this reason, in the configuration of Patent Literature 1, in order to avoid interference between the water pump and the pilot shaft, it is necessary to increase a distance between the drive shaft and the pilot shaft or provide the pilot shaft over the water pump. However, if the distance between the drive shaft and the pilot shaft increases, a length from the pilot shaft to a center of the outboard motor also increases. For this reason, the moment of inertia in rotation of the pilot shaft of the outboard motor also increases, so that steering performance and gliding performance are degraded. In addition, if the pilot shaft is provided over the water pump, it is necessary to shorten the pilot shaft. For this reason, rigidity is degraded in a portion of the ship hull for supporting the outboard motor, and the steering performance is degraded.

CITATION LIST

Patent Literature

Patent Literature 1: Japanese Laid-open Patent Publication No. 6-221383

SUMMARY OF INVENTION

Technical Problem

In view of the aforementioned problems, it is therefore an object of the present invention to provide an outboard motor having a shift unit provided in the middle of the drive shaft that transmits rotational power, capable of operating accessories at all times regardless of the shift position of the shift unit. In addition, it is another object of the present invention to provide an outboard motor having a shift unit provided in the middle of the drive shaft that transmits rotational power, capable of reducing the distance between the drive shaft and the pilot shaft and operating the water pump at all times during the operation of the engine.

Solution to Problem

According to an aspect of the present invention, there is provided an outboard motor including: an engine; a drive shaft extending vertically to transmit rotational power from the engine; a driving gear provided to rotate in synchronization with a lower end of the drive shaft; and a driven gear provided in a propeller shaft rotating in synchronization with a propeller to mesh with the driving gear, wherein the drive shaft has a first input shaft that receives rotational power transmitted from the engine, and a second input shaft that arranged coaxially with the first input shaft to receive rotational power transmitted from the first input shaft, a shift unit is provided between the first and second input shafts to switch a shift position, the shift unit having an upper gear provided in a lower end of the first input shaft to rotate in synchronization, a lower gear provided in an upper end of the second input shaft to rotate relatively to the second input shaft, an intermediate gear provided to rotate in synchronization with an intermediate shaft extending to the rear side perpendicularly to the drive shaft and mesh with the upper and lower gears at all times, and a clutch body that is arranged between the upper and lower gears and rotates in synchronization with the second input shaft to control connection/disconnection of the rotational power from the first input shaft to the second input shaft and switch a rotation direction, while the clutch body moves along the second input shaft to engage with the upper or lower gear, or while the clutch body does not engage with any one of the upper and lower gears, and an accessory is operated by receiving the rotational power transmitted via the intermediate shaft.

In the outboard motor described above, the number of rotation of the intermediate shaft may be different from that of the first input shaft by setting the number of teeth differently between the upper gear and the intermediate gear.

The outboard motor described above may further include a shift actuating unit for moving the clutch body, wherein the shift actuating unit is arranged in front of the drive shaft, and the accessory is arranged in rear of the drive shaft.

In the outboard motor described above, the accessory may have an oil pump that feeds oil to the shift unit, a housing of the oil pump may have a pair of casing members facing each other, and one of the pair of casing members may be integrated to a housing of the shift unit.

According to another aspect of the present invention, there is provided an outboard motor including: an engine; a drive shaft extending vertically to transmit rotational power from the engine; a driving gear provided to rotate in synchronization with a lower end of the drive shaft; a driven gear that is provided in a propeller shaft rotating in synchronization with a propeller and meshes with the driving gear; and a water pump that feeds a coolant to the engine, wherein the drive shaft has a first input shaft that receives the rotational power transmitted from the engine and a second input shaft arranged coaxially with the first input shaft to receive the rotational power transmitted from the first input shaft, a shift unit is provided between the first and second input shafts to switch a shift position, the shift unit has an upper gear provided in a lower end of the first input shaft to rotate in synchronization, a lower gear provided in an upper end of the second input shaft to rotate relatively to the second input shaft, an intermediate gear that is provided to rotate in synchronization with an intermediate shaft extending to the rear side perpendicularly to the drive shaft and meshes with the upper and lower gears at all times, and a clutch body that is arranged between the upper and lower gears and rotates in synchronization with the second input shaft to control connection/disconnection of the rotational power from the first input shaft to the second input shaft and switch a rotation direction, while the clutch body moves along the second input shaft to engage with the upper or lower gear, or while the clutch body does not engage with any one of the upper and lower gears, and the water pump is provided in rear of the shift unit and is operated by the rotational power transmitted to the intermediate shaft.

In the outboard motor described above, a gear ratio between the upper gear and the intermediate gear may be set such that the number of rotation of the intermediate gear is greater than that of the upper gear.

ADVANTAGEOUS EFFECTS OF INVENTION

According to the present invention, accessories are operated by receiving the rotational power transmitted via the intermediate shaft rotating in synchronization with the intermediate gear. Since the intermediate gear meshes with the upper gear provided in the first input shaft at all times, the rotational power is transmitted to the intermediate shaft at all times during the operation of the engine. Therefore, it is possible to operate accessories regardless of the shift position of the shift unit. For example, if an oil pump that feeds oil (lubricating oil) to the shift unit is employed as an accessory, it is possible to feed oil to the shift unit at all times during the operation of the engine.

According to the present invention, since the water pump is provided in rear of the shift unit, it is possible to prevent interference between the water pump and the pilot shaft. For this reason, it is possible to reduce a distance between the drive shaft and the pilot shaft. In addition, since the rotational power is transmitted to the intermediate shaft at all times during the operation of the engine, it is possible to operate the water pump at all times by transmitting the rotational power to the water pump via the intermediate shaft. In this manner, according to the present invention, it is possible to reduce the distance between the drive shaft and the pilot shaft and operate the water pump at all times during the operation of the engine.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a left side view schematically illustrating an exemplary configuration of an appearance of an outboard motor.

FIG. **2** is a partially cross-sectional view schematically illustrating an exemplary configuration of the outboard motor.

FIG. **3** is an enlarged cross-sectional view illustrating an exemplary internal configuration of a lower part of the outboard motor.

FIG. **4** is a cross-sectional view illustrating a forward tilt state of the outboard motor.

FIG. **5** is an exploded perspective view schematically illustrating an exemplary configuration of a shift unit module.

FIG. **6** is a cross-sectional view schematically illustrating an exemplary configuration of a shift unit module.

FIG. **7** is a perspective view schematically illustrating an exemplary configuration of a main part of a shift actuating unit.

FIG. **8** is a top view illustrating a lower unit casing.

DESCRIPTION OF EMBODIMENTS

A description will now be made for an embodiment of the present invention with reference to the accompanying drawings. The embodiment of the present invention relates to an outboard motor having contra-rotating propellers. It is noted that, in each drawing, an arrow "Fr" denotes a front side of the outboard motor, an arrow "Rr" denotes a rear side, an arrow "R" denotes a right side, an arrow "L" denotes a left side, an arrow "Up" denotes an upper side, and an arrow "Dn" denotes a lower side.

<Entire Configuration of Outboard Motor>

A description will be made for the entire configuration of the outboard motor **1** with reference to FIGS. **1** to **3**. FIG. **1** is a left side view schematically illustrating an exemplary configuration of the outboard motor **1**. FIG. **2** is a partially cross-sectional view schematically illustrating an exemplary configuration of the outboard motor **1**. FIG. **3** is an enlarged cross-sectional view illustrating an exemplary internal configuration of the lower part of the outboard motor **1**. As illustrated in FIGS. **1** and **2**, the outboard motor **1** includes an engine cover **101**, a drive shaft housing **102**, and a lower unit casing **103** sequentially from the upside, so that they constitute a housing (exterior) of a main body of the outboard motor **1**. A front propeller **11** and a rear propeller **12** are arranged coaxially in rear of the lower unit casing **103**. The front and rear propellers **11** and **12** are contra-rotating propellers rotating reversely to each other. According to an embodiment of the present invention, it is assumed that, as seen from the rear side, as the front propeller **11** rotates to the right (clockwise), and the rear propeller **12** rotates to the left (counterclockwise), the outboard motor **1** advances forward. A bracket device **14** for installing the outboard motor **1** to a ship hull is provided in front of the drive shaft housing **102**. The outboard motor **1** is installed to a transom or the like of a ship by using the bracket device **14**.

A description will now be made for a configuration of a power transmission system of the outboard motor **1**. As illustrated in FIG. **2**, the outboard motor **1** includes an engine **13** (internal combustion engine) as a driving power source, a propeller shaft **23** rotating in synchronization with the front and rear propellers **11** and **12**, a drive shaft **17** that transmits rotational power of the engine **13** to the propeller shaft **23**, and a shift unit **4** that performs control of connection/disconnection of the rotational power from the engine **13** and switching of the rotation direction. The drive shaft **17** includes first and second input shafts **171** and **172** separated from each other. The shift unit **4** performs control of connection/disconnection of the rotational power and switching of the rotation direction (that is, switching of the shift position) between the first and second input shafts **171** and **172** of the drive shaft **17**. The rotational power output from the engine **13** is transmitted to the front and rear propellers **11** and **12** via the first input shaft **171**, the shift unit **4**, the second input shaft **172**, and the propeller shaft **23**.

As illustrated in FIG. **2**, the engine **13** is housed in the engine cover **101** while it is supported by the engine holder **15** in its upper side. The engine **13** is, for example, a vertical-shaft water-cooled engine. In this case, the engine **13** includes a cylinder head, a cylinder block, a crankcase, and the like. In addition, in the engine **13**, the crankcase is positioned in the frontmost side, the cylinder block is positioned in rear of the crankcase, and the cylinder head is positioned in the rearmost side. Furthermore, an oil pan **16** is disposed under the engine holder **15**.

The first input shaft **171** of the drive shaft **17** is housed in the drive shaft housing **102** such that it can be rotated in a direction extending vertically (its axial line is vertical). An upper end of the first input shaft **171** is connected to the crankshaft of the engine **13**, and a lower end of the first input shaft **171** is connected to the shift unit **4**. In addition, the first input shaft **171** can transmit the rotational power output from the engine **13** to the shift unit **4**.

The shift unit **4** is arranged across the drive shaft housing **102** and the inside of the lower unit casing **103** as seen in a side view. In rear of the shift unit **4**, an oil pump **6** and a water pump **7** as examples of accessories are arranged coaxially along the front-rear direction. The oil pump **6** is actuated by the rotational power transmitted from the shift unit **4** to receive lubricating oil (hereinafter, simply referred to as "oil") inside the lower unit casing **103** through an oil inlet tube **67** and feed the oil to the inside of the shift unit **4**. The water pump **7** is actuated by the rotational power transmitted from the shift unit **4** to feed the coolant to the engine **13**. According to an embodiment of the present invention, the shift unit **4** also has a function of branching the rotational power transmitted from the engine **13** to the accessories in addition to the functions of connection/disconnection of the rotational power between the first and second input shafts **171** and **172** and switching of the rotation direction. In addition, the shift unit **4**, the oil pump **6**, and the water pump **7** are modularized to allow for an integrated assembly work. Here, for the purpose of illustration, the shift unit **4**, the oil pump **6**, and the water pump **7** constitute a "shift unit module." It is noted that the configuration of the shift unit module **104** will be described in more detail below.

Inside the lower unit casing **103**, the second input shaft **172** of the drive shaft **17** is rotatably supported by a bearing **46**. The second input shaft **172** is coaxial with the first input shaft **171** and is disposed under the first input shaft **171** and the shift unit **4**. It is noted that the bearing **46** that supports the second input shaft **172** has a combination of reversely tapered roller bearings in order to endure a radial load and a vertical thrust load. The upper end of the second input shaft **172** is connected to the shift unit **4**, and the second input shaft **172** is arranged to extend vertically downward from the shift unit **4**. The lower end of the second input shaft **172** is provided with a pinion gear **18** as a driving gear rotating in synchronization. For example, the pinion gear **18** is splined to the lower end of the second input shaft **172**. A bevel gear is applied to the pinion gear **18**.

The lower unit casing **103** internally has, under the second input shaft **172**, a bearing housing **20**, a pair of driven gears including front and rear gears **21** and **22**, and a propeller shaft **23** arranged coaxially along the front-rear direction. The front and rear gears **21** and **22** as a pair of driven gears are bevel gears. The propeller shaft **23** includes an outer shaft **232** and an inner shaft **231**. The bearing housing **20** is a tubular member penetrating in the front-rear direction. The bearing housing **20** is detachably fixed by using bolts and the like while it is inserted into the inside of the lower unit casing **103** from the rear side. In addition, the bearing housing **20** rotatably supports the outer shaft **232** and the rear gear **22** with the bearings **238** and **221**.

The front gear **21** is arranged in front of and under the pinion gear **18** and is rotatably supported by a bearing **211** (such as a tapered roller bearing) inside the lower unit casing **103**. The rear gear **22** is arranged in rear of and under the pinion gear **18** and is rotatably supported by a bearing **221** (such as a combination of a thrust needle roller bearing or a thrust cylindrical roller bearing and a cylindrical roller bearing) inside the bearing housing **20**. The front and rear gears **21** and **22** are arranged coaxially side by side along the front-rear direction such that its rotation center extends in the front-rear direction. In addition, the front and rear gears **21** and **22** mesh with the pinion gear **18** provided in the lower end of the second input shaft **172** at all times. For this reason, the front and rear gears **21** and **22** rotate reversely to each other by virtue of the rotational power transmitted from the second input shaft **172**.

The outer shaft **232** is a hollow shaft arranged to extend in the front-rear direction. A middle portion of the longitudinal direction of the outer shaft **232** is inserted into the bearing housing **20**, and the outer shaft **232** is supported by a bearing **238** (such as a needle roller bearing or a cylindrical roller bearing) rotatably with respect to the bearing housing **20**. The rear gear **22** is fixed to the outer circumference of the front end of the outer shaft **232** by nuts and the like. The rear end of the outer shaft **232** protrudes from the bearing housing **20** to the rear side. In addition, the front propeller **11** is provided in the rear end of the outer shaft **232** rotatably in synchronization by a shear pin and the like (not shown).

A middle portion of the longitudinal direction of the inner shaft **231** is loosely inserted into the outer shaft **232** coaxially, and the inner shaft **231** is supported by a bearing **236** (such as a needle roller bearing) rotatably with respect to the inner circumference side of the outer shaft **232**. The front end of the inner shaft **231** protrudes from the outer shaft **232** to the front side and is engaged with the front gear **21** to rotate in synchronization. The rear end of the inner shaft **231** protrudes from the outer shaft **232** to the rear side. In addition, a rear propeller **12** is provided in the rear end of the inner shaft **231** rotatably in synchronization by a shear pin and the like (not shown).

In this manner, the pinion gear **18** serves as a driving gear, and the front and rear gears **21** and **22** serve as driven gears, so that the rotational power transmitted from the second input shaft **172** to the pinion gear **18** is transmitted to both the front and rear gears **21** and **22**. In addition, the front and rear gears **21** and **22** rotate reversely to each other. The rotational power transmitted to the front gear **21** is transmitted to the rear propeller **12** via the inner shaft **231**. The rotational power transmitted to the rear gear **22** is transmitted to the front propeller **11** via the outer shaft **232**. Therefore, the front and rear propellers **11** and **12** rotate reversely to each other.

It is noted that the bearing housing **20**, the rear gear **22**, the outer shaft **232**, and the inner shaft **231** are modularized. In this modularized state, they are detachably assembled to the lower unit casing **103** by a bolt and the like.

As seen in a side view, the shift unit module **104** is arranged over the cavitation plate **105** provided in the lower unit casing **103**, that is, in a position not submerged under the water during use of the outboard motor **1**. In addition, as seen in a side view, the shift unit module **104** is arranged under the lower mount bracket **146** as a mount portion that supports the lower end of the pilot shaft **143**. For this reason, in a submerged portion of the lower unit casing **103**, only the propeller shaft **23** and the gear (pinion gear **18**, front gear **21**, and rear gear **22**) for transmitting the rotational power to the propeller shaft **23** may be provided. In this configuration, it is possible to reduce water resistance by reducing the submerged portion of the lower unit casing **103**.

The bracket device **14** is provided in front of the housing of outboard motor **1** (in particular, in front of the drive shaft housing **102**). The bracket device **14** has a swivel bracket **141** and a transom bracket **142**. The swivel bracket **141** is connected to the front side of the main body of the outboard motor **1** rotatably in a horizontal direction (yawably) with respect to the pilot shaft **143**. The pilot shaft **143** is fixed to the front side of the outboard motor **1** such that its axial line is in parallel with the vertical direction. For example, each of the upper and lower ends of the pilot shaft **143** is fixed to the main body of the outboard motor **1** by using upper and lower mount brackets **145** and **146** as mount portions. It is noted that the pilot shaft **143** has a tubular shape perforated along the axial line. The transom bracket **142** is connected to the swivel bracket **141** rotatably in a pitching direction (pitchably) with respect to a tilt shaft **144**. The tilt shaft **144** is fixed to the swivel bracket **141** such that its axial line is in parallel with the left-right direction. In addition, the transom bracket **142** is provided with a clamp or the like for installation to a transom of a ship. The outboard motor **1** is installed to a transom of a ship by using the transom bracket **142** of the bracket device **14**. Using the bracket device **14** having such a configuration, the outboard motor **1** becomes rotatable horizontally with respect to the pilot shaft **143** and rotatable vertically with respect to the tilt shaft **144** while the outboard motor **1** is installed in a transom and the like of a ship.

It is noted that the upper mount bracket **145** is provided with a steering bracket (not shown). A steering handle (not shown) is connected to the steering bracket with a cable or the like (not shown). A ship operator performs steering of the outboard motor **1** by manipulating the steering handle. In addition, the outboard motor **1** is provided with a trim control device (not shown). This trim device can be used to rotate the outboard motor **1** in a pitching direction by a hydraulic pressure or the like. Furthermore, a ship operator performs tilt or trim adjustment of the outboard motor **1** by manipulating the trim control device.

The outboard motor **1** is further provided with an exhaust passage **25** that guides an exhaust gas of the engine **13** to the outside of the outboard motor **1** and a coolant passage **26** that guides the coolant to the engine **13**.

The exhaust passage **25** includes an upper exhaust passage **251** formed in a rear side of the first input shaft **171** inside the drive shaft housing **102** and a lower exhaust passage **252** formed in a rear side of the shift unit module **104** inside the lower unit casing **103**, so that the exhaust passage **25** extends vertically through the inside. The upper exhaust passage **251** communicates with an exhaust port (not shown) of the engine **13**. The lower exhaust passage **252** communicates with an exhaust duct (not shown), for example, formed in the lower surface of the cavitation plate **105**. In addition, as the lower unit casing **103** is installed to the drive shaft housing **102**, the upper and lower exhaust passages **251** and **252** communicate with each other integratedly. For this reason, an exhaust gas of the engine **13** is discharged to the outside of the outboard motor **1** through the upper and lower exhaust passages **251** and **252** and the exhaust duct.

The coolant passage **26** includes a lower coolant passage **262** formed inside the lower unit casing **103** and an upper coolant passage **261** provided inside the drive shaft housing **102**. The lower coolant passage **262** connects a water inlet port of the lower unit casing **103** and a coolant intake port **721** of the water pump **7** to each other. The upper coolant passage **261** connects a coolant discharge port **711** of the water pump **7** and the engine **13** (more specifically, a water jacket of the engine **13**) to each other. As illustrated in FIGS. **2** and **3**, the upper coolant passage **261** may be a pipeline. In this configuration, the water pump **7** can receive the coolant through the water inlet port and the lower coolant passage **262** and feed the received coolant to the engine **13**.

<Lubrication of Bearing that Rotatably Supports Inner Shaft>

Next, a description will be made for a configuration for lubricating the bearing **236** that rotatably supports the inner shaft **231**. Oil is retained in the lower unit casing **103**. In addition, the lower end of the second input shaft **172**, the pinion gear **18**, the front gear **21**, the rear gear **22**, the inner shaft **231**, and the outer shaft **232** are immersed in the oil. For this reason, these members and bearings **211**, **221**, **236**, and **238** that rotatably support these members are lubricated by the oil retained in the lower unit casing **103**. Meanwhile, since the bearing **236** that rotatably supports the inner shaft **231** is provided in a gap between the outer shaft **232** and the inner shaft **231**, the oil may be accumulated around the bearing **236**, so that deterioration may occur easily. For this reason, lubrication of the bearing **236** may become insufficient in this state, and overheating or the like may occur. In this regard, according to an embodiment of the present invention, the bearing **236** is lubricated by circulating oil based on the following configuration.

A gap is formed between the outer circumferential surface of the outer shaft **232** and the inner circumferential surface of the inner shaft **231**. This gap serves as an oil circulation passage for circulating the oil. In the rear side of the bearing **236** that supports the inner shaft **231**, which is the rear end of the outer shaft **232**, an oil seal **237** for preventing leakage of the oil from this gap to the rear side is provided. Inside the inner shaft **231**, an oil circulation orifice **233** serving as an oil circulation passage is formed. This oil circulation orifice **233** is formed to extend in an axial line of the inner shaft **231** along an axial center of the inner shaft **231**. The front end of the oil circulation orifice **233** is exposed and opened to the front end surface of the inner shaft **231**. The rear end of the oil circulation orifice **233** is positioned between the bearing **236** that supports the inner shaft **231** and the oil seal **237** as seen in a side view. In addition, an oil outlet hole **234** that causes the oil to flow between the rear end of the oil circulation orifice **233** and the outer circumference of the inner shaft **231** is formed between the bearing **236** that supports the inner shaft **231** and the oil seal **237**. Furthermore, a spiral trench **235** for sending the oil from the rear side to the front side is formed on the outer circumferential surface of the inner shaft **231** across a range from the vicinity of the rear side of the rear gear **22** to the vicinity of the front side of the bearing **236**.

As the inner shaft **231** is rotated by virtue of the rotational power transmitted from the engine **13**, the oil inside the oil outlet hole **234** flows to the space between the inner circumferential surface of the outer shaft **232** and the outer circumferential surface of the inner shaft **231** by virtue of a centrifugal force caused by the rotation of the inner shaft **231**. In addition, the resulting oil flows to the front side by the oil subsequently flowing from the oil outlet hole **234**. Furthermore, since the spiral trench **235** is formed in the outer circumferential surface of the inner shaft **231**, the oil is also sent to the front side by virtue of the rotation of the spiral trench **235**. As the oil flows from the oil outlet hole **234**, the inside of the oil circulation orifice **233** has a negative pressure. Therefore, the oil flows from the front end of the inner shaft **231** to the oil circulation orifice **233**. In this manner, it is possible to improve an oil circulation effect by combining the oil circulation orifice **233** and the spiral trench **235**. As a result, while the inner shaft **231** is rotated, it is possible to circulate the oil to the gap between the inner and outer shafts **231** and **232**, the oil circulation orifice **233** of the inner shaft **231**, and the oil outlet hole **234**. For this reason, it is possible to prevent the oil from being accumulated around the bearing **236** that supports the inner shaft **231** and from being deteriorated. Therefore, it is possible to prevent a failure such as overheating of the bearing **236** that supports the inner shaft **231** and improve integrity.

It is noted that the spiral trench **235** of the outer circumference of the inner shaft **231** is formed to send the oil from the rear side to the front side when the outboard motor **1** makes a forward travel. If the outboard motor **1** makes a forward travel when the rear propeller **12** and the inner shaft **231** make a left turn as described above, the spiral trench **235** is formed in a right-handed thread manner.

In this configuration, even when the outboard motor **1** has a front tilt posture as illustrated in FIG. **4**, it is possible to lubricate the bearing **236** that supports the inner shaft **231**. FIG. **4** is a cross-sectional view schematically illustrating a condition of the oil when the outboard motor **1** has a front tilt posture. As illustrated in FIG. **4**, even when the outboard motor **1** has the front tilt posture, the front end of the inner shaft **231** is immersed to the oil. For this reason, as the inner shaft **231** rotates, the oil inside the oil outlet hole **234** is discharged to the gap between the outer shaft **232** and the inner shaft **231** by virtue of the centrifugal force. As a result, the inside of the oil circulation orifice **233** has a negative pressure, and the oil is pumped up through the oil circulation orifice **233**. In this manner, even when the outboard motor **1** has a front tilt posture, and the bearing **236** that supports the inner shaft **231** is positioned higher than the oil surface, it is possible to circulate the oil and feed the oil to the bearing **236** that supports the inner shaft **231**.

<Configuration of Shift Unit Module>

Next, a description will be made for a configuration of the shift unit module **104** with reference to FIGS. **5** to **7**. FIG. **5** is an exploded perspective view schematically illustrating an exemplary configuration of the shift unit module **104**. FIG. **6** is a cross-sectional view schematically illustrating an exemplary configuration of the shift unit module **104**. FIG. **7** is a perspective view illustrating an exemplary configuration of the shift actuating unit **5** of the shift unit **4**.

As illustrated in FIGS. **5** and **6**, the shift unit module **104** has the shift unit **4**, the oil pump **6**, and the water pump **7**. In addition, the oil pump **6** is arranged in rear of the shift unit **4**, and the water pump **7** is arranged in rear of the oil pump **6**. In addition, in the shift unit **4**, the shift actuating unit **5** that performs switching of the shift position is arranged in front of the first and second input shafts **171** and **172**. In this manner, the oil pump **6** and the water pump **7** as examples of accessories are coaxially arranged in the rear side, and the shift actuating unit **5** is arranged in the front side while they are interposed between the first and second input shafts **171** and **172**. In addition, the shift unit module **104** is fixed to the lower unit casing **103** by a bolt and the like. For this reason, as the lower unit casing **103** is removed from the drive shaft housing **102**, the shift unit module **104** is separated from the drive shaft housing **102** along with the lower unit casing **103**.

In particular, as illustrated in FIG. **5**, the shift unit **4**, the oil pump **6**, and the water pump **7** are subsidiary modules of the shift unit module **104**. That is, the shift unit module **104** is obtained by individually assembling the shift unit **4**, the oil pump **6**, and the water pump **7** and further installing the oil pump **6** and the water pump **7** to the shift unit **4**.

<Shift Unit>

As illustrated in FIG. **6**, the shift unit **4** includes a shift housing **40**, an upper gear **41**, an intermediate gear **42**, a lower gear **44**, a dog clutch **45** (clutch body), and a shift actuating unit **5**.

The shift housing **40** is a housing of the shift unit **4** and has an upper half **401** and a lower half **402**. In addition, the shift housing **40** is provided separately from any one of the lower unit casing **103** and the drive shaft housing **102** of the outboard motor **1**. The upper and lower halves **401** and **402** can be divided vertically with respect to a plane perpendicular to the axial lines of the first and second input shafts **171** and **172** as a dividing plane. The dividing plane between the upper and lower halves **401** and **402** is formed near a dividing plane between the drive shaft housing **102** and the lower unit casing **103** as seen in a side view (refer to FIGS. **2** and **3**). In addition, the dividing plane between the upper and lower halves **401** and **402** matches or is in parallel with the dividing plane between the drive shaft housing **102** and the lower unit casing **103**. Referring to FIGS. **2** and **3**, for example, the dividing plane between the upper and lower halves **401** and **402** matches the dividing plane between the drive shaft housing **102** and the lower unit casing **103**. In this configuration, while the shift unit module **104** is assembled to the housing of the outboard motor **1**, the upper part of the shift unit module **104** is housed in the drive shaft housing **102**, and the lower part is housed in the lower unit casing **103**. However, the dividing plane between the upper and lower halves **401** and **402** of the shift housing **40** may not necessarily match the dividing plane between the drive shaft housing **102** and the lower unit casing **103** unlike the aforementioned configuration. Furthermore, in the rear part of the shift housing **40**, an oil pump housing cover **62** as one of a pair of casing members included in the oil pump housing **60** as a housing of the oil pump **6** is formed integratedly.

The upper gear **41** is provided in the lower end of the first input shaft **171** to rotate in synchronization with the first input shaft **171**. For example, the upper gear **41** is splined to the lower end of the first input shaft **171**. In addition, the upper gear **41** is rotatably supported by a bearing **412** (such as a radial ball bearing or a radial roller bearing) inside the upper half **401** of the shift housing **40**. Furthermore, the upper gear **41** transmits, to the intermediate gear **42**, the rotational power transmitted from the engine **13** via the first input shaft **171** at all times.

An oil passage **403** extending from the oil pump housing cover **62** to the upper part of the bearing **412** that rotatably supports the upper gear **41** is formed in the shift housing **40**. The oil pump **6** feeds the oil to the upper part of the bearing **412** that rotatably supports the upper gear **41** through the oil passage **403**.

The intermediate gear **42** is provided between the upper and lower gears **41** and **44** and meshes with them at all times. The intermediate gear **42** is rotatably supported by a bearing **421** (such as a tapered roller bearing) inside the shift housing **40**. In addition, the intermediate gear **42** is arranged to extend in the front-rear direction behind the upper and lower gears **41** and **44** as seen in a side view or a top view such that its rotational axis is perpendicular to the rotational axes of the upper and lower gears **41** and **44**.

An intermediate shaft **43** rotating in synchronization is coupled to the intermediate gear **42**. The intermediate shaft **43** protrudes from the shift housing **40** to the rear side in a direction perpendicular to the drive shaft **17** (first input shaft **171** and second input shaft) and transmits the rotational power to both the oil pump **6** and the water pump **7**. In this manner, according to an embodiment of the present invention, the intermediate shaft **43** acts as a pump drive shaft for the oil pump **6** and the water pump **7**.

The intermediate gear **42** and the upper gear **41** have different number of teeth, and the intermediate gear **42** rotates at a rotation number different from that of the upper gear. The gear ratio between the intermediate gear **42** and the upper gear **41** is set depending on specifications of accessories driven by the intermediate shaft **43**. That is, the gear ratio is set such that the intermediate shaft **43** has an appropriate rotation number depending on specifications of accessories driven by the intermediate shaft **43**. In this manner, if the accessories are driven by the intermediate shaft **43**, it is possible to easily set the rotation number of the intermediate shaft **43** suitably to drive the accessories by appropriately setting the gear ratio between the intermediate gear **42** and the upper gear **41**.

In particular, if the oil pump **6** and the water pump **7** are employed as accessories, the gear ratio between the intermediate gear **42** and the upper gear **41** is set such that the rotation number of the intermediate gear **42** (rotation number of the intermediate shaft **43**) is greater than the rotation number of the upper gear **41** (rotation number of the first input shaft **171**). For example, the number of teeth of the intermediate gear **42** is set to be smaller than that of the upper gear **41**. As the rotation number of the intermediate shaft **43** acting as a pump drive shaft increases, the amount of oil or coolant output from the oil pump **6** or the water pump **7** increases. For this reason, by increasing the rotation number of the intermediate shaft **43**, it is possible to miniaturize the oil pump **6** and the water pump **7** without reducing the output amount of the oil or coolant. Therefore, by setting the gear ratio such that the rotation number of the intermediate gear **42** is greater than that of the upper gear **41**, it is possible to reduce the size and weight of the shift unit module **104**.

The lower gear **44** is arranged coaxially with the upper gear **41** under the upper gear **41** with a predetermined distance. The lower gear **44** is rotatably supported by a bearing **442** (such as a radial ball bearing or a radial roller bearing) inside the lower half **402** of the shift housing **40**. The lower gear **44** receives the rotational power transmitted from the upper gear **41** via the intermediate gear **42** and rotates reversely to the upper gear **41**.

The upper end of the second input shaft **172** protrudes to the gap between the upper and lower gears **41** and **44** through an axial bore of the lower gear **44**. It is noted that a bearing **47** (such as a radial needle roller bearing) is provided between the axial bore of the lower gear **44** and the second input shaft **172** so that the lower gear **44** and the second input shaft **172** can rotate (relatively) independently.

A dog clutch **45** is provided between the upper and lower gears **41** and **44**. The dog clutch **45** is splined to, for example, the outer circumferential surface of the upper end of the second input shaft **172** so that it can rotate in synchronization with the second input shaft **172** and reciprocate in an axial line direction (vertically) on the second input shaft **172**. Locking dogs **451** are formed on both upper and lower end surfaces of the dog clutch **45**. In addition, locking dogs **411** and **441** are also formed on the lower surface of the upper gear **41** and the upper surface of the lower gear **44**, respectively. In addition, as the dog clutch **45** moves upward, the locking dog **451** of the upper end surface of the dog clutch **45** is engaged with the locking dog **411** of the lower surface of the upper gear **41**, so that the dog clutch **45** rotates in synchronization with the upper gear **41**. Meanwhile, as the dog clutch **45** moves downward, the locking dog **451** of the lower end surface of the dog clutch **45** is engaged with the locking dog **441** of the upper surface of the lower gear **44**, so that the dog clutch **45** rotates in synchronization with the lower gear **44**. If the dog clutch **45** is placed in a center of the vertical movement range, the locking dogs **451** on both upper and lower end surfaces of the dog clutch **45** are not engaged with any one of the locking dogs **411** and **441** of the upper and lower gears **41** and **44**. In this case, the rotational power of the first input shaft **171** is not transmitted to the second input shaft **172**.

Since the intermediate gear **42** and the upper gear **41** mesh with each other at all times, the rotational power of the engine **13** is transmitted to the intermediate shaft **43** via the upper gear **41** and the intermediate gear **42** at all times regardless of the position of the dog clutch **45**. In this manner, while the engine **13** is operated, and the first input shaft **171** rotates, it is possible to transmit the rotational power to the intermediate shaft **43** in a constant direction at all times regardless of whether or not the rotational power is transmitted to the second input shaft **172**.

The shift actuating unit **5** is provided in front of the dog clutch **45** (that is, in front of the first and second input shafts **171** and **172**). As illustrated in FIG. **7**, the shift actuating unit **5** includes a shift cam **51** and a shift slider **52**. The shift cam **51** is a cylindrical cam having a cam groove on its side surface. The shift cam **51** is connected to the lower end of the shift shaft **55** so that it rotates in the left-right direction by virtue of the rotational power transmitted via the shift shaft **55**. The shift slider **52** is provided to reciprocate along the slide shaft **53**. In addition, a part of the shift slider **52** is engaged with the cam groove of the shift cam **51** and protrudes to the rear side, and the shift slider **52** has an arm **521** engaged with the dog clutch **45**. It is noted that the slide shaft **53** is supported by the shift housing **40** while its axial line is arranged in parallel with the first and second input shafts **171** and **172**.

Furthermore, the outboard motor **1** has an actuator as a power source for driving the shift cam **51** and a shift shaft **55** for transmitting the drive power of the actuator **54** to the shift cam **51** as rotational power. The actuator **54** is provided, for example, in the inner or lower surface of the engine cover **101**. The shift shaft **55** is rotatably inserted into the inside of the tubular pilot shaft **143** to extend vertically (refer to FIG. **2**). In addition, the upper end of the shift shaft **55** is connected to the actuator **54**, and the lower end is connected to the shift cam **51** of the shift actuating unit **5**.

Moreover, by actuating the actuator **54**, it is possible to rotate the shift cam **51** in any one of the left and right directions.

The operation of the shift unit **4** will be described. As a ship operator operates the actuator **54**, the shift shaft **55** rotates in any one of the left and right directions. As the actuator **54** is operated, the shift shaft **55** rotates in a direction corresponding to the direction of the rotational power generated by the actuator **54**, so that the shift cam **51** rotates in synchronization with the shift shaft **55**. As the shift cam **51** rotates, the shift slider **52** shifts the dog clutch **45** upward or downward depending on the rotation direction of the shift cam **51**.

As the dog clutch **45** moves upward, the dog clutch is engaged with the upper gear **41**, so that it rotates in synchronization with the upper gear **41**. Since the dog clutch **45** rotates in synchronization with the second input shaft **172**, the rotational power of the engine **13** is transmitted to the second input shaft **172** via the first input shaft **171**, the upper gear **41**, and the dog clutch **45**. It is noted that, in this case, the second input shaft **172** rotates in the same direction as that of the first input shaft **171**. Meanwhile, as the dog clutch **45** moves downward, the dog clutch **45** is engaged with the lower gear **44** so that it rotates in synchronization with the lower gear **44**. For this reason, the rotational power of the engine **13** is transmitted to the second input shaft **172** via the first input shaft **171**, the upper gear **41**, the intermediate gear **42**, the lower gear **44**, and the dog clutch **45**. In this case, the second input shaft **172** rotates reversely to the first input shaft **171**. The rotational power transmitted to the second input shaft **172** is further transmitted to the rear propeller **12** via the pinion gear **18**, the front gear **21**, and the inner shaft **231**, and is then transmitted to the front propeller **11** via the pinion gear **18**, the rear gear **22**, and the outer shaft **232**. In addition, if the dog clutch **45** is placed in the center of the vertical movement range, both the locking dogs **451** on the upper and lower ends of the dog clutch **45** are not engaged with the locking dogs **411** and **441** of the upper and lower gears **41** and **44**. In this case, the rotational power output from the engine **13** is not transmitted to the second input shaft **172**. Therefore, the shift position is set to a neutral position. In this manner, since the dog clutch **45** moves upward or downward by rotating the shift cam **51**, it is possible to set the shift position to any one of forward, backward, and neutral positions.

According to the embodiment of the present invention, the shift position is set to the forward position when the locking dog **451** of the upper end of the dog clutch **45** is engaged with the locking dog **411** of the upper gear **41**. Meanwhile, when the locking dog **451** of the lower end of the dog clutch **45** is engaged with the locking dog **441** of the lower gear **44**, the shift position is set to the backward position. As a result, when the shift position is set to the backward position, the rotational power of the engine **13** is transmitted to the second input shaft **172** via the upper gear **41**, the intermediate gear **42**, and the lower gear **44**. Typically, when the shift position is set to the backward position, the transmitted power is smaller than that of the forward position. For this reason, it is possible to weaken the strengths of the upper gear **41**, the intermediate gear **42**, and the lower gear **44**. Therefore, it is possible to miniaturize these gears. Accordingly, it is possible to reduce the size and weight of the shift unit **4**.

The shift unit **4** is provided with a position holding mechanism **56** for holding the shift position. The position holding mechanism **56** has, for example, three engagement concave portions **561** formed in the outer circumferential surface of the shift cam **51**, an engagement member **562** removably fitted to the engagement concave portion **561**, and a biasing member (not shown) for maintaining the state of the engagement member **562** fitted to the engagement concave portion **561**. The engagement member **562** is provided reciprocatably with respect to the shift housing **40** and is biased to the outer circumferential surface of the shift cam **51** by a biasing member such as a spring. The three engagement concave portions **561** are provided to receive the fitted engagement member **562** in each of the forward, backward, and neutral positions. In this configuration, while no external force is applied to the shift cam **51**, the engagement member **562** is held in a state fitted to any one of the three engagement concave portions **561**. For this reason, the shift position is held. It is noted that, in order to change the shift position, the shift cam **51** is rotated by exerting a certain level of force by using the actuator **54**. Then, the engagement member **562** is released from the engagement concave portion **561** against the biasing force of the biasing member by virtue of the rotation of the shift cam **51**. It is noted that, in order to implement such a function, the leading edge of the engagement member **562** (the portion fitted to the engagement concave portion **561**) may be formed in a tapered shape, and a cross section of the engagement concave portion **561** perpendicular to the axial line of the shift cam **51** may have a "V" shape or a circular arc shape.

As described above, according to the embodiment of the present invention, the dog clutch **45** as a mechanism for controlling connection or disconnection of the rotational power is provided between the first and second input shafts **171** and **172**. In this configuration, it is possible to facilitate miniaturization of the shift unit **4**. That is, for example, if a friction clutch such as a cone clutch is used to transmit the rotational power of the engine **13**, it is necessary to increase a pressing force for pressing the driven frictional surface toward the driving frictional surface and an area of the frictional surface in order to transmit high rotational power. This increases the size and weight of the shift unit **4**. In particular, when a cone clutch is employed as the friction clutch, a dimension of the clutch in the axial line direction increases in order to enlarge the friction area. For this reason, if the shift unit **4** is provided under the lower mount bracket **146**, in order to avoid interference between the shift unit **4** and the lower mount bracket **146**, it is necessary to place the lower mount bracket **146** in a higher position and shorten the pilot shaft **143**. In this case, the rigidity of the bracket device **14** may be reduced, and steering performance may be degraded disadvantageously.

In this regard, according to an embodiment of the present invention, the locking dog **451** of the dog clutch **45** is engaged with the locking dogs **411** or **441** of the upper and lower gear **41** or **44**, so that the rotational power is transmitted. As a result, it is possible to miniaturize the dog clutch **45**. In addition, since it is not necessary to apply a strong pressing force to the dog clutch **45** in the axial line direction, it is possible to miniaturize the shift actuating unit **5** for actuating the shift unit **4**. Furthermore, a small-sized configuration can be applied to the actuator **54** and the like for rotating the shift shaft **55**. Therefore, it is possible to reduce the size and weight of the shift unit **4**.

<Accessories>

Next, a description will be made for the oil pump **6** and the water pump **7** as examples of the accessories with reference to FIGS. **5** and **6**. The oil pump **6** and the water pump **7** are operated by the rotational power transmitted from the intermediate shaft **43** by using the intermediate shaft **43** as a common pump drive shaft.

<Oil Pump>

According to an embodiment of the present invention, for example, a trochoid pump is employed as the oil pump **6**. The oil pump **6** (trochoid pump) includes an oil pump housing **60**, an inner rotor **64**, an outer rotor **65**, a pump body **63**, and a bearing **66**.

The oil pump housing **60** is a housing of the oil pump **6** and includes a pair of casing members, specifically, an oil pump housing body **61** and an oil pump housing cover **62**. The oil pump housing body **61** has a cup or tray shape having an opened front side. The oil pump housing body **61** is internally provided with, from the front side, a space for housing the pump body **63** and a space for housing the bearing **66** (such as a cone roller bearing). In addition, the oil pump housing body **61** is provided with an oil intake port **611** for receiving oil from the outside and an oil discharge port **612** for discharging the oil to the outside. Furthermore, the oil pump housing body **61** has a through-hole penetrating in the front-rear direction to allow the intermediate shaft **43** to be inserted. The oil pump housing cover **62** is integratedly provided in the rear part of the shift housing **40** (upper and lower halves **401** and **402**) of the shift unit **4**. It is noted that the oil pump housing cover **62** covers the opening of the oil pump housing body **61**. In addition, as described above, the oil pump housing cover **62** (upper half **401** of the shift housing **40**) is provided with an oil passage **403** for feeding the oil to the inside of the shift housing **40**. One end of the oil passage **403** is exposed to the rear face of the oil pump housing cover **62**. As the oil pump housing body **61** is installed to the oil pump housing cover **62**, the oil passage **403** communicates with the oil discharge port **612** of the oil pump housing body **61**. It is noted that any configuration may be employed as the oil pump housing cover **62** without a particular limitation if it can block the opening of the oil pump housing body **61**.

A circular concave portion is formed on the front surface side of the pump body **63** as seen in a front view. This concave portion can rotatably house the outer rotor **65** and the inner rotor **64**. A through-hole penetrating in the front-rear direction to receive the inserted intermediate shaft **43** is formed on the bottom of the circular concave portion in a decentered position. Furthermore, an oil intake hole **631** and an oil discharge hole **632** are formed on the bottom of the concave portion.

The inner rotor **64** has a plurality of triangular teeth bulging to the outside of the radial direction with a predetermined thickness. The inner rotor **64** is provided with an axial bore penetrating in the front-rear direction (thickness direction) and receiving the inserted intermediate shaft **43**. The outer rotor **65** has a circular shape, as seen in a front view, with a predetermined thickness. The outer rotor **65** has an opening penetrating in the front-rear direction (thickness direction), and a plurality of triangular teeth bulging to the inside of the radial direction are formed on the inner circumferential surface of the opening. It is noted that the number of teeth formed in the outer rotor **65** is greater than the number of teeth formed in the inner rotor **64**.

An assembly structure of the oil pump **6** will be described. The bearing **66** and the pump body **63** are housed in the oil pump housing body **61**. It is noted that the pump body **63** is housed so as not to rotate with respect to the oil pump housing body **61**. As the pump body **63** is housed in the concave portion of the oil pump housing body **61**, the oil intake hole **631** and the oil discharge hole **632** of the pump body **63** communicate with the oil intake port **611** and the oil discharge port **612**, respectively, of the oil pump housing body **61**. It is noted that one end of the oil intake pipe **67** is connected to the oil intake port **611**. The other end of the oil intake pipe **67** reaches the front side of the second input shaft **172** inside the lower unit casing **103**. The outer rotor **65** is rotatably housed in a circular concave portion provided in the pump body **63**. The inner rotor **64** is housed in the opening provided in the outer rotor **65**. In addition, the oil pump housing body **61** is fixed to the oil pump housing cover **62** formed in the rear part of the shift housing **40** with a bolt and the like. In addition, the oil pump housing body **61** is covered by the oil pump housing cover **62**. As a result, the inner rotor **64** and the outer rotor **65** are rotatably housed in the space formed by the oil pump housing body **61** and the shift housing **40**. Furthermore, the oil discharge port **612** of the oil pump housing body **61** communicates with the oil passage **403** formed in the oil pump housing cover **62** (upper half **401** of the shift housing **40**). While the oil pump **6** is assembled to the shift unit **4**, the intermediate shaft **43** penetrates the axial bore of the inner rotor **64**, the through-hole of the pump body **63**, the bearing **66**, and the opening of the oil pump housing body **61** and then protrudes to the rear side. It is noted that the inner rotor **64** is coupled to the intermediate shaft **43** with a key and the like so that they rotate in synchronization. In addition, since the through-hole of the pump body **63** is decentered from the circular concave portion, the inner rotor **64** is also decentered from the outer rotor **65**.

In this manner, the oil pump housing body **61** and the oil pump housing cover **62** constitute the oil pump housing **60**. In addition, the oil pump housing cover **62** is formed integratedly with the shift housing **40**. In this configuration, it is not necessary to separately provide an independent oil pump housing cover. In addition, the oil passage **403** extending from the oil pump **6** to the upper side of the bearing **412** that rotatably supports the upper gear **41** can be formed integratedly with the shift housing **40**. Therefore, it is possible to miniaturize the shift unit module **104** and simplify the structure of the shift unit module **104**.

The operation of the oil pump **6** will be described. As the rotational power of the engine **13** is transmitted to rotate the intermediate shaft **43**, the inner rotor **64** rotates in synchronization with the intermediate shaft **43**. A part of the teeth of the inner rotor **64** mesh with the teeth of the outer rotor **65**. Therefore, as the inner rotor **64** rotates, the outer rotor **65** also rotates. Since the inner rotor **64** is decentered from the outer rotor **65**, and they have different number of teeth, a volume of the gap formed between the inner rotor **64** and the outer rotor **65** changes depending on a circumferential position of the gap as they rotate. In addition, the oil intake hole **631** of the pump body **63** is formed in a position where the volume of this gap starts to increase, and the oil discharge hole **632** is formed in a position where the volume of the gap starts to decrease after it is maximized. For this reason, as the inner rotor **64** and the outer rotor **65** rotate along with the rotation of the intermediate shaft **43**, the oil retained in the lower unit casing **103** is suctioned through the oil intake pipe **67** and the oil intake port **611** and is discharged from the oil discharge port **612**. In addition, the suctioned oil is discharged to the upper side of the bearing **412** that rotatably supports the upper gear **41** through the oil passage **403** formed in the upper half **401** of the shift housing **40**. The discharged oil lubricates the bearing **412**, and then flows down while it lubricates each member provided in the shift housing **40**. Furthermore, the oil flows along the outer circumference of the second input shaft **172** and reaches the inside of the lower unit casing **103**. In this manner, the oil pump **6** can feed the oil to the shift unit **4** of the outboard motor **1** for lubrication.

<Water Pump>

According to an embodiment of the present invention, for example, the water pump **7** has a multiblade rotor **73** (impeller). The water pump **7** includes a water pump housing body **71**, a water pump housing cover **72**, a multiblade rotor **73**, and a panel member **74**.

The water pump housing body **71** and the water pump housing cover **72** constitute a housing of the water pump **7**. The water pump housing body **71** is opened in its front side and has a circular concave portion as seen in a front view. In addition, this circular concave portion acts as a rotor housing chamber for rotatably housing the multiblade rotor **73**. Furthermore, the water pump housing body **71** is provided with a coolant discharge port **711** for discharging the coolant from the internal space to the outside. The water pump housing cover **72** is a member for covering the front side of the water pump housing body **71**. The water pump housing cover **72** is provided with a through-hole that can receive the inserted intermediate shaft **43** and a coolant intake port **721** for suctioning the coolant from the outside. The multiblade rotor **73** has a plurality of elastically deformable blades extending to the outside in a radial direction. The panel member **74** is provided with a through-hole that can receive the inserted intermediate shaft **43** and a coolant intake hole **741** where the coolant passes.

An assembly structure of the water pump **7** will be described. The multiblade rotor **73** is rotatably housed in the rotor housing chamber of the water pump housing body **71**. In this state, leading edges of the blades of the multiblade rotor **73** make contact with the inner circumferential surface of the rotor housing chamber. In addition, the multiblade rotor **73** is coupled to the rear end of the intermediate shaft **43** so that it rotates in synchronization with the intermediate shaft **43**. It is noted that a rotation center of the multiblade rotor **73** is decentered upward from the center of the circular rotor housing chamber. In addition, the panel member **74** is arranged in front of the water pump housing body **71**, and the water pump housing cover **72** is further arranged in front of the panel member **74**. Gaskets **75** are interposed between the panel member **74**, the water pump housing body **71**, and the water pump housing cover **72**. In addition, the water pump housing body **71** and the water pump housing cover **72** are coupled to each other by a bolt and the like. In this case, the panel member **74** or the gasket **75** is also fixed by a bolt and the like at the same time.

The operation of the water pump **7** will be described. As the intermediate shaft **43** rotates by virtue of the rotational power from the engine **13**, the multiblade rotor **73** rotates in synchronization with the intermediate shaft **43**. Since the multiblade rotor **73** is decentered upward, a volume of the space formed by the blades of the multiblade rotor **73** and the inner circumferential surface of the rotor housing chamber is reduced as the multiblade rotor **73** rotates and moves upward. In comparison, the volume of this space increases as the multiblade rotor **73** moves downward. In addition, the inlet hole of the panel member **74** is decentered, as seen in a front view, downward from the center of the intermediate shaft **43**. Meanwhile, the coolant discharge port **711** is formed on top of the water pump housing body **71**. For this reason, the water pump **7** can suction the coolant from the coolant intake port **721** and discharge it from the coolant discharge port **711**.

As the shift unit module **104** is assembled to the outboard motor **1**, the coolant intake port **721** of the water pump **7** communicates with a lower coolant passage **262** of the lower unit casing **103**, and the coolant discharge port **711** is connected to an upper coolant passage **261**. For this reason, if the multiblade rotor **73** rotates as the intermediate shaft **43** rotates, the water pump **7** receives the coolant from the outside through the water inlet port of the lower unit casing **103**, the lower coolant passage **262**, and the coolant intake port **721**. In addition, the water pump **7** feeds the coolant to the engine **13** through the coolant discharge port **711** and the upper coolant passage **261** of the drive shaft housing **102**.

As described above, according to an embodiment of the present invention, the oil pump **6** is arranged in rear of the shift unit **4**, and the water pump **7** is arranged in rear of the oil pump **6**. The oil pump **6** and the water pump **7** are arranged coaxially along the front-rear direction, and the intermediate shaft **43** acts as a common pump drive shaft. As described above, the intermediate shaft **43** is arranged to rotate in synchronization with the intermediate gear **42**. For this reason, while the engine **13** is operated, and the crankshaft rotates, the intermediate shaft **43** rotates in a constant direction at all times regardless of the shift position of the shift unit **4**. Therefore, the oil pump **6** and the water pump **7** are operated continuously while the first input shaft **171** rotates.

It is notated that, although the aforementioned configuration includes, for example, the oil pump **6** and the water pump **7**, the present invention is not limited thereto. Any configuration may be employed if the oil pump **6** and the water pump **7** can be operated by the rotational power transmitted from the outside through a common intermediate shaft **43**.

Since the shift unit **4**, the oil pump **6**, and the water pump **7** are modularized in an integrated manner, a work for assembling them to the outboard motor **1** is easy in a production line. In addition, it is possible to simplify the production line of the outboard motor **1** and reduce the manufacturing cost. Furthermore, since they can be checked or exchanged in a modularized state, it is possible to improve quality.

The upper gear **41** and the intermediate gear **42** mesh with each other at all times, and the rotational power is transmitted to the intermediate shaft **43** at all times during the operation of the engine **13**. For this reason, during the operation of the engine **13**, it is possible to operate the oil pump **6** and the water pump **7** by rotating the intermediate shaft **43** in a constant direction at all times regardless of the shift position of the shift unit **4**. In addition, in this configuration, it is possible to achieve miniaturization, compared to a configuration in which the water pump **7** is directly provided in the first input shaft **171**. That is, the amount of the coolant discharged by the water pump **7** increases as the rotation number of the multiblade rotor **73** increases. As described above, the gear ratio between the intermediate gear **42** and the upper gear **41** is set such that the rotation number of the intermediate shaft **43** is greater than that of the first input shaft **171**. For this reason, when the water pump **7** is operated by using the intermediate shaft **43** as a pump drive shaft, it is possible to achieve miniaturization without reducing the amount of the discharged coolant, compared to a case where the first input shaft **171** is used as the pump drive shaft.

Since the shift unit **4**, the oil pump **6**, and the water pump **7** are modularized, it is possible to achieve miniaturization in the entire structure. In particular, since the oil pump housing cover **62** is integrated to the rear part of the shift housing **40** of the shift unit **4**, it is possible to miniaturize the oil pump **6**.

According to the embodiment of the present invention, since the water pump **7** as an accessory is provided in rear of the shift unit **4**, it is possible to simplify the configuration around the first input shaft **171**. For this reason, it is possible to reduce a distance between the first input shaft **171** and the pilot shaft **143**. For example, when the water pump **7** is provided coaxially with the first input shaft **171**, it is necessary to increase the distance between the first input shaft **171** and the pilot shaft **143** or arrange the water pump **7** over or under the pilot shaft **143** in order to avoid interference between the water pump **7** and the pilot shaft **143**. However, in the former configuration, since the moment of inertia in rotation of the pilot shaft **143** of the outboard motor **1** increases, the steering performance is degraded. Furthermore, the center of the outboard motor **1** recedes from a ship hull, gliding performance (acceleration performance) is degraded.

Meanwhile, in the latter configuration, it is necessary to shorten the pilot shaft **143**. Therefore, the rigidity of the bracket device **14** is lowered, and the steering performance is degraded.

In comparison, according to the embodiment of the present invention, since the water pump **7** is provided in rear of the first input shaft **171**, no interference is generated between the water pump **7** and the pilot shaft **143**. For this reason, it is possible to reduce the distance between the pilot shaft **143** and the drive shaft **17**. In this configuration, it is possible to reduce the moment of inertia in the rotation of the pilot shaft **143** of the outboard motor **1** and allow the center of the outboard motor **1** to approach the ship hull. Therefore, it is possible to improve steering performance and gliding performance. In addition, since accessories such as the water pump **7** are not arranged over the shift unit **4**, it is possible to allow the lower mount bracket **146** that supports the lower end of the pilot shaft **143** to be close to the shift unit **4**. For this reason, it is possible to improve the rigidity of the bracket device **14** by lengthening the pilot shaft **143** and improve steering performance. Furthermore, since the shift unit **4** is arranged under the lower mount bracket **146**, it is possible to prevent interference between the shift unit **4** and the pilot shaft **143** and allow the pilot shaft **143** and the drive shaft **17** to be close to each other.

When the water pump **7** is provided in rear of the shift unit **4**, it is possible to lower the arrangement position of the water pump **7** to be close to the water surface, compared to the configuration in which the water pump **7** is provided in the first input shaft **171**. For this reason, it is possible to improve pump efficiency of the water pump **7**. It is noted that the shift unit module **104** including the water pump **7** is positioned higher than the cavitation plate **105**, as seen in a side view, where it is not submerged under the water during the use. Therefore, there is no need to worry about an increase of water resistance that may be caused when the submerged portion of the lower unit casing **103** increases.

When the water pump **7** is provided in rear of the oil pump **6**, maintainability of the water pump **7** is improved. The water pump **7** may suction a foreign object such as sand along with the coolant in some times. For this reason, it is necessary to perform periodic maintenance due to wear of the multiblade rotor **73** and the like. In comparison, since the oil pump **6** does not suction a foreign object, maintenance frequency is reduced, compared to the water pump **7**. In this regard, since the water pump **7** is provided in rear of the oil pump **6**, it is possible to perform maintenance of the water pump **7** (in particular, inspection of the multiblade rotor **73** and the like) without removing or disassembling the oil pump **6**. Therefore, it is possible to improve maintainability of the water pump **7**.

FIG. **8** is a top plan view illustrating a state that the lower unit casing **103** is removed from the drive shaft housing **102**. The shift unit **4**, the oil pump **6**, and the water pump **7** are detachably installed to the lower unit casing **103** by a bolt and the like. For this reason, when the lower unit casing **103** is removed from the drive shaft housing **102**, the shift unit module **104** is separated from the drive shaft housing **102** along with the lower unit casing **103**. As illustrated in FIG. **8**, the rear part of the water pump **7** faces the exhaust passage **25** to form an empty space. In this manner, since the water pump **7** is provided to face the exhaust passage **25**, and there is a space in its vicinity, it is possible to facilitate maintenance of the water pump **7**. For example, it is possible to facilitate installation or uninstallation of the water pump **7**.

While the embodiments of the present invention have been described hereinbefore in detail with reference to the accompanying drawings, it would be appreciated that they are merely intended to illustrate specific examples of the present invention and are not intended to limit the scope of the invention. Instead, various changes or modifications can be possible without departing from the spirit and scope of the present invention.

INDUSTRIAL APPLICABILITY

The present invention is appropriately applied to an outboard motor having a shift unit. According to the present invention, it is possible to operate accessories during the operation of the engine regardless of the shift position of the shift unit. In addition, according to the present invention, it is possible to reduce the distance between the drive shaft and the pilot shaft and operate the water pump during the operation of the engine at all times.

The invention claimed is:

1. An outboard motor comprising:

an engine;

a drive shaft extending vertically to transmit rotational power from the engine;

a driving gear provided to rotate in synchronization with a lower end of the drive shaft; and

a driven gear provided in a propeller shaft rotating in synchronization with a propeller to mesh with the driving gear,

wherein the drive shaft has a first input shaft that receives rotational power transmitted from the engine, and a second input shaft that is arranged coaxially with the first input shaft to receive rotational power transmitted from the first input shaft,

a shift unit is provided between the first and second input shafts to switch a shift position,

the shift unit having

an upper gear provided in a lower end of the first input shaft to rotate in synchronization,

a lower gear provided in an upper end of the second input shaft to rotate relatively to the second input shaft,

an intermediate gear provided to rotate in synchronization with an intermediate shaft extending to the rear side perpendicularly to the drive shaft and mesh with the upper and lower gears at all times, and

a clutch body that is arranged between the upper and lower gears and rotates in synchronization with the second input shaft to control connection/disconnection of rotational power from the first input shaft to the second input shaft and switch a rotation direction, while the clutch body moves along the second input shaft to engage with the upper or lower gear, or while the clutch body does not engage with any one of the upper and lower gears, and an accessory is operated by receiving the rotational power transmitted via the intermediate shaft.

2. The outboard motor according to claim **1**, wherein the number of rotation of the intermediate shaft is different from that of the first input shaft by setting the number of teeth differently between the upper gear and the intermediate gear.

3. The outboard motor according to claim **1**, further comprising a shift actuating unit for moving the clutch body,

wherein the shift actuating unit is arranged in front of the drive shaft, and the accessory is arranged in rear of the drive shaft.

4. The outboard motor according to claim **3**, wherein the accessory includes an oil pump that feeds oil to the shift unit,

a housing of the oil pump includes a pair of casing members facing each other, and

one of the pair of casing members is integrated to a housing of the shift unit.

5. An outboard motor comprising:

an engine;

a drive shaft extending vertically to transmit rotational power from the engine;

a driving gear provided to rotate in synchronization with a lower end of the drive shaft;

a driven gear provided in a propeller shaft rotating in synchronization with a propeller to mesh with the driving gear; and

a water pump that feeds a coolant to the engine,

wherein the drive shaft has a first input shaft that receives rotational power transmitted from the engine, and a second input shaft that is arranged coaxially with the first input shaft to receive rotational power transmitted from the first input shaft,

a shift unit is provided between the first and second input shafts to switch a shift position,

the shift unit having

an upper gear provided in a lower end of the first input shaft to rotate in synchronization,

a lower gear provided in an upper end of the second input shaft to rotate relatively to the second input shaft,

an intermediate gear provided to rotate in synchronization with an intermediate shaft extending to the rear side perpendicularly to the drive shaft and mesh with the upper and lower gears at all times, and

a clutch body that is arranged between the upper and lower gears and rotates in synchronization with the second input shaft to control connection/disconnection of rotational power from the first input shaft to the second input shaft and switch a rotation direction, while the clutch body moves along the second input shaft to engage with the upper or lower gear, or while the clutch body does not engage with any one of the upper and lower gears, and

the water pump is provided in rear of the shift unit and is operated by rotational power transmitted to the intermediate shaft.

6. The outboard motor according to claim **5**, wherein a gear ratio between the upper gear and the intermediate gear is set such that the number of rotation of the intermediate gear is greater than that of the upper gear.

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